NRIC National Reactor Innovation Center

U.S. Advanced Reactor Demonstrations & NRIC

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U.S. Advanced Reactors

- Dozens of companies
  - Sizes range from ~1MWe to ~1000MWe
  - Variety of coolants (gas, sodium, salt, lead, water, etc.)
  - Private investment
- Motivation
  - Clean, reliable, increased efficiency
  - Potential for improved nuclear resource utilization and reduced nuclear waste
  - Diverse markets

Image courtesy of GAIN and Third Way, inspired by the *Nuclear Energy Reimagined* concept led by INL. Learn more about these and other energy park concepts at thirdway.org/blog/nuclear-reimagined

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Historical Context

- **Reactor Demonstration Programs**
  - Atomic Energy Commission
  - National Reactor Testing Station
  - Production Reactors
  - Cooperative Power Reactor Demonstration Program
  - International Development
  - NGNP
- **Recent Policy Actions**
  - Nuclear Energy Innovation Capabilities Act
  - Nuclear Energy Innovation Modernization Act
  - Advanced Reactor Demonstration Program
  - Energy Act of 2020

NE Advanced Reactor Development - Mission & Objectives

Mission: Support the development and commercialization of innovative concepts including microreactor, fast reactor, molten salt reactor (MSR), and high temperature gas-cooled reactor (HTGR) technologies through national laboratory-led R&D, university research programs, and cost-shared private-public industry partnerships.

Objectives:

- Conduct focused research and development to reduce technical barriers to deployment of advanced nuclear energy systems
- Develop technologies that can enable new concepts and designs to achieve enhanced affordability, safety, sustainability and flexibility of use
- Sustain technical expertise and capabilities within national laboratories and universities to perform needed research
- Engage with Standards Developing Organizations (SDO's) to address gaps in codes and standards to support advanced reactor designs
- Collaborate with industry and Nuclear Regulatory Commission (NRC) to identify and conduct essential research to reduce technical and regulatory risk associated with advanced reactor technologies

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NE Advanced Reactor Development R&D Campaigns

- Fast Reactor Technologies
  - Demonstrate feasibility of advanced systems and component technologies
  - Methods and code validation to support design and licensing
  - Qualification of legacy metallic fast reactor fuel performance data
- Gas Reactor Technologies
  - Advanced alloy and graphite materials qualification
  - Scaled integral experiments to support design and licensing
  - TRISO-coated particle fuel development and qualification
- Molten Salt Reactor Technologies
  - Investigate fundamental salt properties
  - Materials, models, fuels and technologies for salt-cooled and salt-fueled reactors
- Microreactors
  - Non-nuclear and nuclear integrated system testing supporting commercial demonstrations and end-user applications
  - Maturation of innovative components and semi-autonomous operating regimes

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Other NE Programs Supporting Advanced Reactor Development

- Advanced Reactor Demonstration Program (ARDP)
  - Major cost-shared awards to construct and demonstrate two concepts in 5-7 years
  - Other cost-shared awards supporting development of emerging innovative concepts
- National Reactor Innovation Center (NRIC)
  - Supporting domestic advanced reactor demonstrations by establishing innovative testing infrastructure, performing siting analyses, and conducting stakeholder outreach
- Advanced Reactor Regulatory
  - Crosscutting non-LWR licensing framework activities
  - Close collaboration with campaigns, industry stakeholders, and NRC
- Nuclear Cybersecurity
  - Developing methods and technologies for cost-effective, cyber-secure digital instrumentation, control, and communication for current and future nuclear plants
- Advanced Reactor Safeguards
  - Developing optimized methods and technologies for advanced reactors to meet domestic materials accountancy and physical protection requirements
- Integrated Energy Systems
  - Developing tools and technologies to support the demonstration and commercialization of a broad range of non-electric applications for current and future nuclear plants

DOE Fuel Cycle Programs Supporting Advanced Reactor Development

- **Mission:** to **enable innovation** and the implementation of advanced technologies to **optimize** U.S. nuclear energy systems and to support U.S. industry opportunities for global deployment
- Shifting emphasis towards balanced portfolio to support **Advanced Reactor Demonstration and Deployment** and **Innovative Fuel Cycle R&D for the future**
- **Versatile Test Reactor**: An essential domestic capability to support the development of innovative fuels, materials and technologies
- **Fuel for Advanced Reactors**: Metal, carbides, nitrides, and dissolved/liquid fuel concepts
- **Recycling Technologies**: To sustain options for improved fuel utilization and higher performing waste forms
- **Material Protection, Accounting and Control Technologies (MPACT)**: To improve fuel cycle efficiency and effectiveness in accountancy and proliferation resistance
- **Systems Analysis**: To improve fuel cycle efficiency and effectiveness in accountancy and proliferation resistance

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Advanced Reactor Demonstration Program

- Objectives:
  - Develop, construct, and demonstrate several advanced reactors with beneficial capabilities
  - Support diversity of advanced designs
  - Stimulate private sector companies/supply chains
- Funding pathways aligned with varied maturity levels:
  - Advanced Reactor Demonstration (Demos) awards
  - Risk Reduction for Future Demonstration (Risk Reduction) awards
  - Advanced Reactor Concepts-20 (ARC-20) awards

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Demonstration

Natrium Reactor
Sodium-cooled fast reactor + molten salt energy storage system
TERRAPOWER

Xe-100
High-temperature gas reactor
X-ENERGY

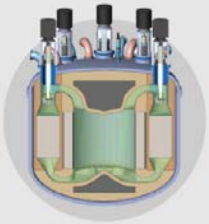
Risk Reduction

KP-FHR
Fluoride salt-cooled high-temperature reactor
KAIROS POWER

eVinci
Heat pipe-cooled microreactor
WESTINGHOUSE NUCLEAR

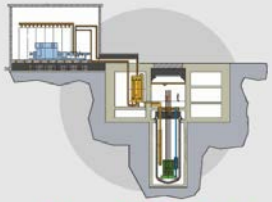
BWXT Advanced Nuclear Reactor (BANR)
High-temperature gas-cooled microreactor
BWX TECHNOLOGIES

SMR-160
Advanced light-water small modular reactor
HOLTEC INTERNATIONAL



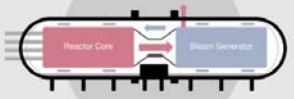
Molten Chloride Fast Reactor
SOUTHERN COMPANY

Concept Development



Advanced Sodium-Cooled Reactor Facility
ADVANCED REACTOR CONCEPTS

Fast Modular Reactor
GENERAL ATOMICS



Horizontal Compact High-Temperature Gas Reactor
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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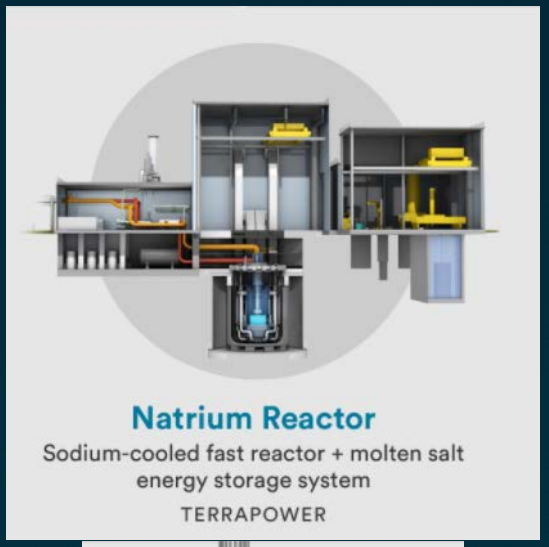
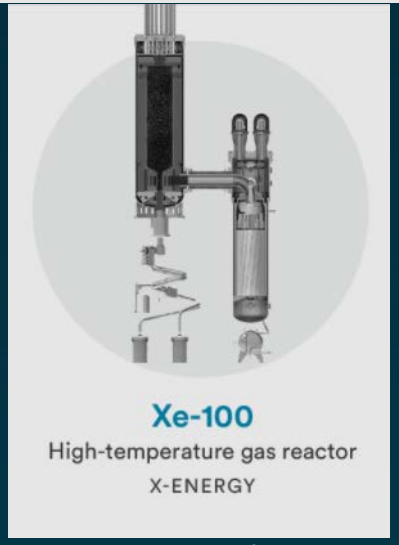
Demonstration Pathway Selected Technologies

- TerraPower LLC – Natrium Reactor
  - SFR that leverages decades of fast reactor and metallic fuel development
  - High temperature reactor coupled with thermal energy storage for flexible electricity output
  - New metal fuel fabrication facility
  - Visit: https://natriumpower.com/

- X-energy – Xe-100 reactor
  - HTGR that leverages decades of reactor and robust TRISO fuel form development
  - Provides flexible electricity output and process heat for a wide range of industrial heat applications
  - Commercial scale TRISO fuel fabrication facility
  - Visit: https://x-energy.com/





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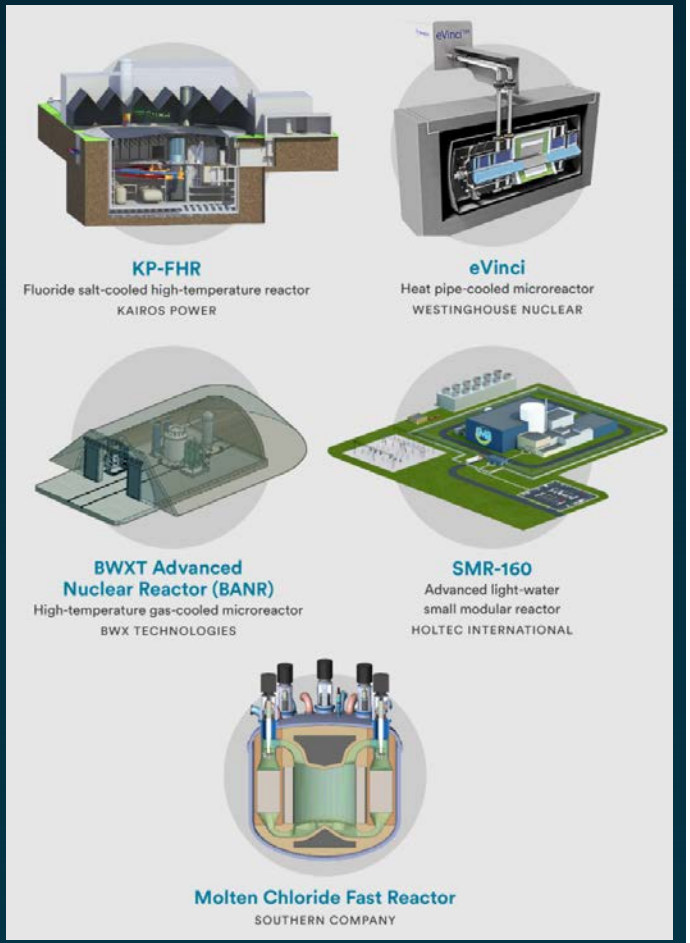
Risk Reduction Pathway Selected Technologies

Prime Recipient	Commercial Target Reactor Type and Fuel	Risk Reduction Project Key Deliverables
Kairos Power. LLC	KP-FHR - 140 Mwe thermal spectrum fluoride salt-cooled MSR, TRISO annular pebble fuel	Design, construction and operation of Hermes reduced-scale test reactor (precursor to commercial-scale KP-FHR)
Westinghouse	eVinci - 4.5 MWe heat pipe-cooled microreactor, TRISO UCO compact HALEU fuel	Technical risk reduction for moderator design, wick manufacturing, refueling and licensing.
BWXT	BANR - 50 MWt transportable microreactor HTGR with UN TRISO	Maturation of technology, including the development of UN TRISO fuel, to improve the commercial viability of BANR
Holtec	SMR-160 - 160 MWe LW-cooled natural circulation PWR	Early stage design, engineering, and licensing activities for the SMR-160.
Southern Company	Molten Chloride Fast Reactor – 180 MWt pool-type MSR fast reactor with liquid salt fuel	Design, construction and operation of Molten Chloride Reactor Experiment (MCRE)



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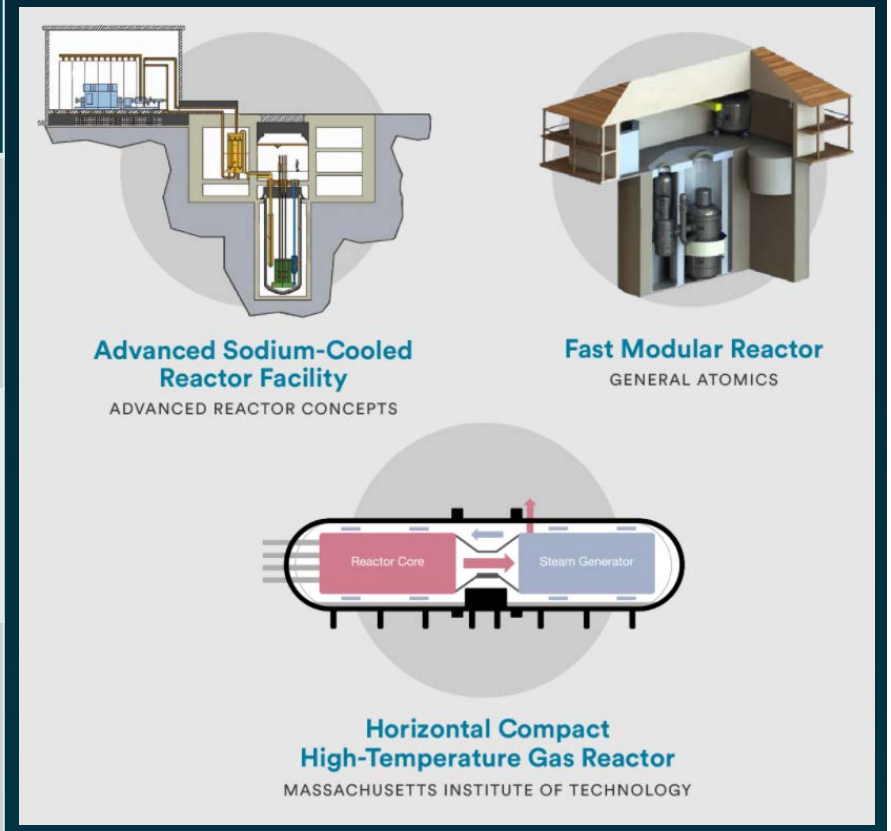
ARC-20 Selected Technologies

Prime Applicant	Commercial Target Reactor Type	ARC-20 Project Key Deliverables
Advanced Reactor Concepts	**ARC-100 100 MWe pool type sodium-cooled fast reactor**	Conceptual and preliminary design of a seismically isolated advanced sodium-cooled reactor facility
General Atomics	**GA-EMS 50 MWe gas-cooled fast modular reactor**	Conceptual design of the GA-EMS 50 MWe FMR, increase TRL on systems and components, develop prelim. cost estimates
MIT	**Modular Integrated Gas-cooled High Temperature Reactor (MIGHTR)**	Conceptual design for MIGHTR and support for future commercialization as a safe and cost-competitive HTGR concept



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deliver
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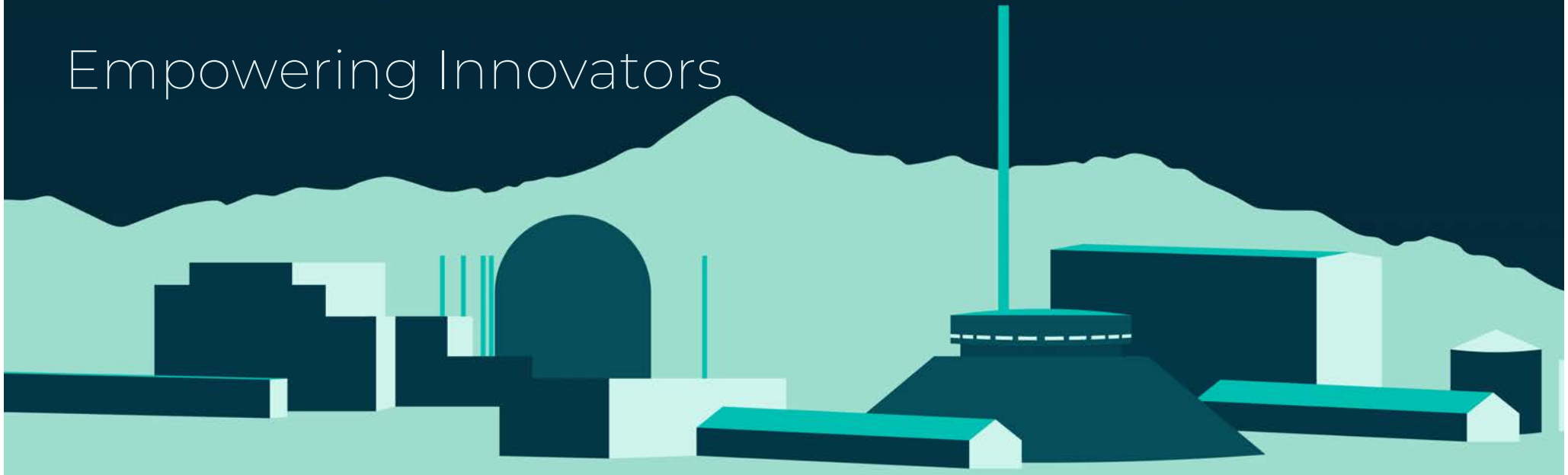
Empowering Innovators



- Demonstration Resource Network
  - Test beds & Demonstration Sites
  - Experimental & Fuel Facilities
    - Irradiation & Characterization
    - Component testing (sodium, helium, molten salt, lead, etc.)
- Regulatory Risk Reduction
- Virtual Test Bed
- NRIC Resource Team

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Delivering Successful Outcomes

- Coordination & Collaboration
- Digital Engineering
- Advanced Construction Technology
- Integrated Energy Systems
- MARVEL
- Construction project management

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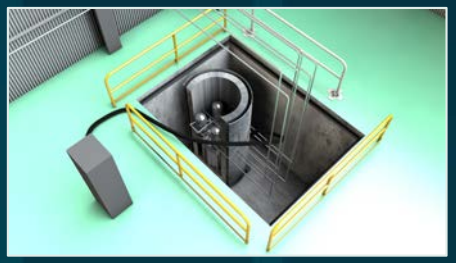
MARVEL: Microreactor Applications Research, Validation and Evaluation Project

- 100 kWth/20 kWe microreactor
- Experience base for NRIC
  - Rapid demonstration at national lab
  - **NEPA evaluations**
  - **Operator readiness and training**
  - **Safety basis**
  - Engineering, design, assembly

Site: TREAT Storage Pit (8'x12'x10') and TREAT control room



Reactor in TREAT storage pit

Control Room

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NRIC is a National Program and Central Integrator for Partners and Collaborators

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Thank you!

Questions?

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